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FUTURE LOGGING EQUIPMENT NEEDS IN COASTAL B.C. (1969-2005)

BY
E.A. SAUDER, R.P.F

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SUMMARY

The purpose of this report is to identify the areas where the Coastal industry will be operating in the period 1985 to 2005 and the logging equipment and systems it will need to harvest these areas profitably.

The objectives for the study were:

1. to document current cut volumes, age classes (mature or second growth), and cutting areas in Coastal B.C.;

2. to identify, in cooperation with the B.C. Ministry of Forests and Lands and the forest products companies, future cut volumes, age classes, and cutting areas;

3. to document the current logging-equipment complement, by subclasses, in Coastal B.C. and any trends in equipment selection;

4. to identify the type and amount of new equipment and systems required to log the future stands; and

5. to predict the proportion of future stands which can be profitably harvested with current equipment and systems.

Two questionnaires were prepared and used as a basis for discussion. A detailed questionnaire was completed by 27 divisional engineers from industry. A total of 13 individuals, including regional engineers representing industry and resource officers from the Ministry of Forests and Lands, completed a general questionnaire.

The survey results were tabulated, percentage changes calculated, comments summarized, and trends noted. The data is presented as trends that are forecast to occur in three zones of the Coast. No attempt is made to translate these trends to the total actual Coast harvest, but the survey respondents are responsible for approximately half of the Annual Allowable Cut on the Coast.

Trends are forecast for three zones: the South Zone, the Mid Zone, and the North Zone. The South Zone represents logging operations in the Fraser, Soo, and Sunshine Coast Forest Districts and the portion of the Arrowsmith Forest District south of the Tree Farm Licence (TFL) 44 south boundary. The Mid Zone includes logging operations in the Kingcome and Strathcona Forest Districts and the portion of the Arrowsmith Forest District north of the TFL 44 southern boundary. The North Zone represents the Prince Rupert, Queen Charlotte, Midcoast, and Kalum Forest Districts.

The survey indicates that there will be no change in Coastal production between the years 1985 and 2005, although a peak is expected in 1995. On a regional basis, the Southern and Northern Zones will decrease in production while the Mid Zone will increase in production for the period 1985 to 2005.

Five factors identified during the discussions indicate the timber supply on the Coast will be more expensive to recover and may not be sufficient to meet future demand. These are:

1. the isolated nature of the remaining old-growth stands;

2. insufficient inventory data for the remaining old-growth stands;

3. reduced flexibility in operating areas because Small Business Enterprise Programs are becoming area based;

4. timber requirements beyond the current charted licences appear to be insufficient; and

5. less flexibility in changing operating areas or increasing annual allowable cuts.

There will be increased pressure from the forest industry to log second-growth or young stands and less opportunity to pick-up extra volumes from alternate tenures. Equipment utilization will probably decrease. No shift in the balance of production between summer and winter operations is expected. The survey found that there would be a slight reduction in operating days per year over the period but no major shift.

Equipment needs will be influenced by the predicted harvests, the projected number of operating days per year, and the logging season. South Zone equipment fleets will probably be reduced or adjacent operating areas consolidated. Rather than increase the equipment fleet, the Mid Zone will probably increase equipment utilization to increase the harvest. Equipment will probably have to be added to the North Zone fleet during the 1985 to 1995 period if increased utilization is not sufficient to meet the projected 1995 harvests. Beyond 1995, the North Zone equipment fleet will probably decrease.

The majority of survey respondents feel that ground roughness, steepness of sideslopes, and elevation of operating areas on the average will not change significantly over the 20-year period. For example, in the South Zone, although there will be more higher-elevation timber, this will be offset by more timber becoming available at lower elevations. The survey indicates that, overall, more timber will be on slopes greater than 50% and less on slopes less than 30%. The South Zone will actually have an increase of timber available on gentler slopes whereas the Mid and North Zones will reflect the overall Coastal trend. In terms of percentage of timber available at different elevations, there will be no shift on the overall Coast, although in the South Zone there will be a shift to lower elevation (<750 m) timber.

Ground-based systems will probably have greater potential in the South Zone as slope steepness, ground roughness, and elevation of operating areas decrease. Cable yarding will probably remain the dominant system in the Mid and North Zones because terrain features are not forecast to change. Road construction is expected to become easier in the South Zone as increased logging occurs on low-elevation, previously logged areas. Road construction in the Mid and North Zones is expected to increase in difficulty.

Overall, timber species and size are forecast to change very little on the Coast. The South Zone is the exception where a shift to Douglas-fir and a smaller piece average is forecast. All respondents feel there would be a reduction in recovery over the 20-year period because of lower-quality stands. Stand characteristic changes which are forecast in the South Zone reflect the predicted shift from old-growth to second-growth harvesting. Age and height classes will stay essentially the same in the Mid and North Zones but volume per hectare and piece size are predicted to decline. Old-growth timber will be depleted within 30 years in the South Zone, while the Mid and North Zones have old-growth volumes available beyond 40 years.

The general decline in piece size means that in order to recover the predicted volumes, it will be necessary to handle more pieces than in 1985. There will probably also be an increased utilization of the logs extracted. Ground-based extraction systems and mechanical felling will have potential (especially on South Zone slopes less than 30 percent). Cable yarders and loaders will be required to have fast cycle times or the ability to handle several pieces at the same time. Full-tree logging will continue in order to separate the extraction and loading phases. Equipment may not decrease in size. It would appear the greatest potential for changing equipment fleets will occur in the South Zone.

Timber developed per kilometre of road will decline slightly reflecting the reduction in timber quality and the increase in terrain difficulty. As a result, more road will be constructed in 2005 than 1985 to access basically the same amount of timber. Reconstructed subgrade will form a higher proportion of road construction lengths in all areas, particularly in the South Zone. In the South and Mid Zones the proportion of main to branch road construction will decrease, but in the North Zone it will increase slightly. In the North Zone, operations will still be moving into new drainages by the year 2005. Rock will continue to be a major component of road construction.

Indications are that the future harvest volumes will be more difficult to obtain and will be more expensive to develop. Overhead costs are expected to rise as allowable harvest levels reduce, equipment utilization decreases, and operations shift to developing smaller drainages. Harvesting costs will rise because of reductions in piece size and timber quality, and road costs will increase as a result of construction on steeper hillsides. Some reduction in extraction costs will occur in the South and Mid Zones as increased volumes of second-growth timber are harvested.

Environmental concerns may restrict the use of ground-based equipment in the South Zone. Mechanical felling equipment may have the potential to directionally fell timber beside or within streamside management zones. Road location, road construction, cutblock design and harvesting treatments would be influenced by their impact on aesthetics.

Respondents indicate the estimated fleet of road-construction equipment will decline over the 20-year period even though more roads will be built and it is expected more rock will be encountered. This decline is attributed to the use of more productive equipment and because of higher utilization (double shifting). Mechanical felling is predicted to increase

in the South and Mid Zones but, because of the newness of the concept on the Coast, most respondents could not provide specific details. Respondents indicate cable logging will continue to be the dominant harvesting system, but with a slight increase in the volume harvested by ground skidding. The number of pieces of ground-skidding equipment required is forecast to decrease, however, this is probably a reflection of the uncertainty of how second-growth stands will be logged. The number of cable-yarding machines is also estimated to decline over the 20-year period. This is a result of a trend to replace highlead towers with more productive grapple yarders and yarding cranes. However, the highlead tower will still remain an important part of the cable-yarding fleet.

The use of mechanized processing equipment is expected to increase over the 20-year period particularly in the South and Mid Zones. The estimates of the increase are felt to be conservative because mechanized processing is relatively new and most respondents had not fully considered how they could use the concept. The number of log loaders required will decrease over the 20-year period in response to the shift in type of cable-yarding equipment. The mix of log-loading equipment will shift to more hydraulic log loaders and fewer cable log loaders.

The total number of logging trucks is expected to decline and there will be a shift from off-highway and highway-size pole trailers to highway-size multi-axle trailers. Hauling distances will remain the same or decline in the South and Mid Zone, and increase slightly in the North Zone. The switch to higher-capacity multi-trailers is the main reason for the decline in the total number of trucks in the 20-year period.

The estimated road-construction fleet appears to be conservative considering the reduction in timber developed per km of road and the increased volume that is to be harvested in the Mid to North Zones. Predictions for the mechanical felling-equipment fleet are also felt by FERIC to be very conservative and will increase significantly when more operations see the benefits to be gained from their use, or equipment is designed to handle the low-value timber. The benefits to be realized from using ground-based systems as opposed to cable systems is also not fully appreciated in the South and Mid Zones. If the volume of timber to be harvested by different cable systems is accurately presented by the respondents, it would appear that an over-optimistic level of production is anticipated from multiple-shifting yarding equipment. Highlead, tower-skyline, and long-line skyline yarding have little potential for working multi-shift days. If the revised ground-skidding harvest volumes are achieved, the cable-yarding fleet (primarily grapple yarders) will be reduced proportionately. Predictions for the mechanical processing-equipment fleet are also significantly underestimated because of a lack of information regarding the equipment and the lack of equipment to handle the timber.

There appears to be major potential for using mechanical felling, ground-skidding, and processing equipment in Coastal B.C. Mechanical felling equipment could be used to reduce felling costs, to create bunches to maximize extraction equipment payloads, to recover trees from leave strips, and to increase safety. The equipment must be capable of handling rough terrain,

moving large windfalls, and operating on slopes averaging 50 percent. Ground-skidding equipment would require high flotation capability and would have to be large enough to handle the large old-growth pieces encountered within second-growth stands. Processing equipment would have to handle tree-length logs from roadside windrows.

Although all respondents agree that they would eventually have to address the question of harvesting economically inaccessible timber, they do not feel they would actually have to harvest a significant amount of timber from these stands in the next 20 years. They feel that some stands which are economically inaccessible for manual felling and cable yarding could be economically harvested using mechanical-felling and ground-skidding equipment during the 1995 to 2005 period.

As identified in this survey, the greatest impediments to utilization of new equipment appear to be:

1. a lack of understanding of new systems, techniques, and equipment;
2. the concern that the current labour contract limits the introduction of new contract operations;
3. the impressions that the future harvest volumes are available in sufficient volumes to meet the demands;
4. that existing equipment can recover the majority of the timber; and
5. a lack of demand for fibre that could be obtained from low-quality timber.

These impediments can be combined with the natural resistance to change and the need to supervise new equipment more intensively than conventional equipment.

This report indicates the future harvest levels will be more difficult and more costly to achieve. Equipment development, progressive thinking, monetary incentives, and cooperation between management and labour are required to overcome the terrain and timber characteristics that will make future logging more difficult.

INTRODUCTION

The cost of harvesting and extracting B.C. Coastal timber has been increasing steadily. Indications are that in the next 20 years the logging industry will encounter a number of factors which will contribute to even higher costs. These include rougher terrain, smaller timber, lower-quality timber, longer transport distances, higher road-building costs, and stricter environmental rules. While all these factors are not likely to be of concern in every location, the presence of only one or two will increase costs. The future scenario appears to be a choice between high-cost logs or reduced volumes. If true, neither choice is attractive to Coastal companies or employees.

If the effect of these predictions is to be minimized, then it is important that the site and stand characteristics of the future cutting areas be documented and the appropriate existing harvesting systems be applied or new harvesting systems be developed.

The purpose of this report is to identify the areas where the Coastal industry will be operating in the period 1985 to 2005 and the logging equipment and systems it will need to harvest these areas profitably.

The objectives for the study are:

1. to document current cut volumes, age classes (mature or second growth), and cutting areas in Coastal B.C.;

2. to identify, in cooperation with the B.C. Ministry of Forests and Lands and the forest products companies, future cut volumes, age classes, and cutting areas;

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STUDY METHODS

Two questionnaires were prepared and used as a basis for discussion. A detailed questionnaire was completed by 27 divisional engineers from industry. A total of 13 individuals, including regional engineers representing industry and resource officers from the Ministry of Forests and Lands, completed a general questionnaire.

The survey results were tabulated, percentage changes calculated, comments summarized, and trends noted. The data is presented as trends that are forecast to occur in three zones of the Coast. No attempt is made to translate these trends to the total actual Coast harvest.

SURVEY AREA

The area for the survey includes the Vancouver Forest Region and the North Coast and Kalum Forest Districts of the Prince Rupert Forest Region. The Coastal area was subdivided into three zones (South, Mid, and North) for purposes of data analysis and to identify regional trends (Figure A). The subdivision represents areas with similar logging histories.

The South Zone represents logging operations in the Fraser, Soo, and Sunshine Coast Forest Districts and the portion of the Arrowsmith Forest District south of the Tree Farm Licence (TFL) 44 south boundary. The Mid Zone includes logging operations in the Kingcome and Strathcona Forest Districts and the portion of the Arrowsmith Forest District north of the TFL 44 southern boundary. The North Zone represents the Prince Rupert, Queen Charlotte, Midcoast, and Kalum Forest Districts.

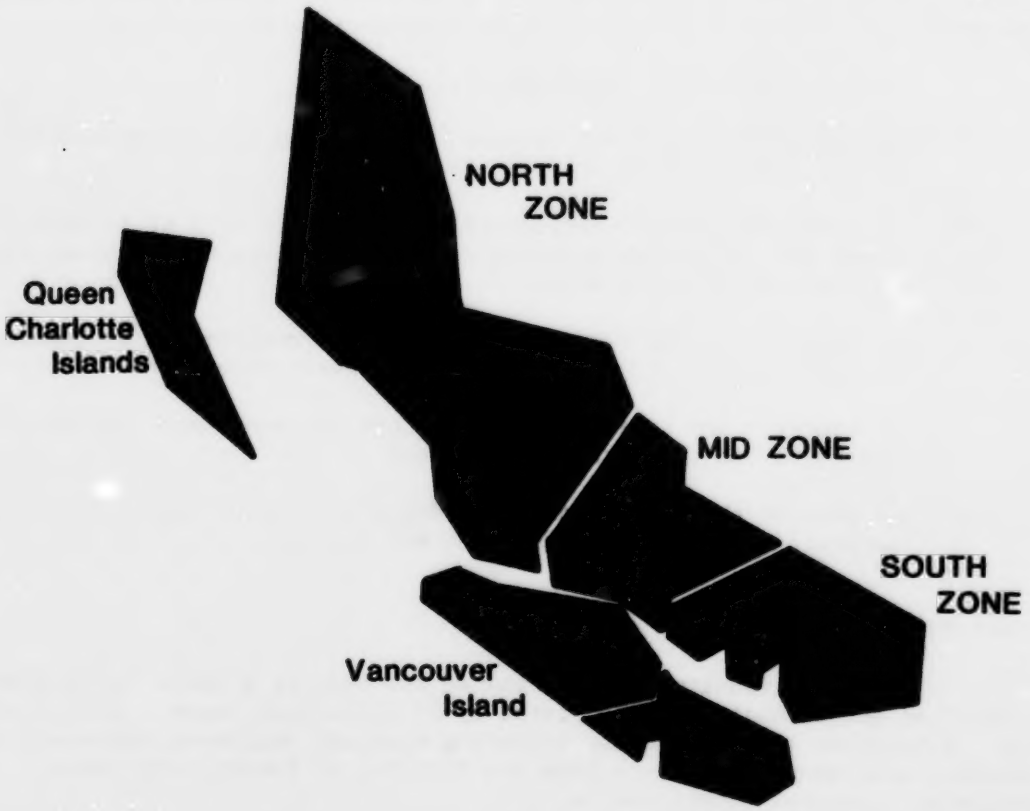

FIGURE A. Survey Area.

Table 1 summarizes the size range of the operations surveyed and the number of samples obtained in each region. Data collected at each division included all the subdivisions or contractors the management unit oversaw. As a result, a wide range of logging operations are included in the survey results. Overall, the survey represents approximately 50% of the 1985 Coastal log harvest.

TABLE 1. Summary of Survey Participants.

Zone	No. of Interviews	1985 Cut[1] (x 1000 m^3)	% of Total Survey	Size of Logging Units (x 1000 m^3)	1985 Annual Volume[3] (x 1000 m^3)	% of Annual Volume
South	10 (4)[2]	3 601.0	24	104-810	8 603.4	29
Mid	13 (5)	8 983.2	59	315-1565	16 358.2	54
North	4 (4)	2 520.3	17	162-1388	5 071.0	17
TOTAL	27 (13)	15 104.5	100		30 032.6	100

[1] Includes all company and contract operations under the interviewees responsibility.

[2] No. of informal interviews.

[3] Figures from 1985/1986 Annual Report Vancouver Forest Region; and G.S. Nagle, M.R.C. Massie, G. Robinson, P. Oakley, and G. Manning. 1987. The Economics of Residual Fuel and Fibre Production on The B.C. Coast. Pacific Forestry Centre Information Report BC-X-289.

RESULTS OF THE SURVEY

I. PRODUCTION, TIMBER, AND TERRAIN CHARACTERISTICS

A. Coast Logging Production

Survey respondents' Coastal harvesting plans fro 1985, 1995, and 2005 are summarized in Table 2. Total production will increase by 7% from 1985 to 1995 and decline 7% from 1995 to 2005. Thus, there is virtually no change in production from 1985 to 2005.

TABLE 2. Summary of Coast Logging Volumes (m^3).

Tenure	Actual Harvest 1985	Forecast Harvest 1995	Forecast Harvest 2005
TFL	9 524 500	10 580 000	10 266 500
OTT[1]	1 381 800	1 470 100	122 000
TSA[2]	2 007 400	2 241 000	2 952 000
Private	2 190 800	1 877 000	1 826 500
TOTAL	15 104 500	16 168 100	15 167 000

[1] Old Temporary Tenures (Timber and Pulp Licences).
[2] Timber Supply Area.

1. South Zone

The South Zone (Table 3) will experience a reduction over the period of 1985 to 2005. The reduction in planned private timber harvests is due to a reducing inventory and a need to re-align the volume of timber available in the various age classes for future rotations. The harvesting of Timber and Pulp Licences is expected to be uniform until 1995 and will thereafter decrease until the licences expire (2005-2010). TFL and Timber Supply Area (TSA) harvests will increase to offset the foregoing declines.

Indications are that the licensees will have difficulty in achieving the budgeted volumes in 2005, although the inventory data indicates the volumes which are forecast are available. Reductions may be required when new inventory data is available and to balance old-growth and second-growth harvest levels. Thinnings are considered an additional potential source of timber that, in 2005, could be harvested if there are shortages.

TABLE 3. Summary of South Zone Logging Volumes (m^3).

Tenure	Actual Harvest 1985	Forecast Harvest 1995	Forecast Harvest 2005
TFL	1 315 000	1 400 000	1 405 000
OTT	201 800	245 100	0
TSA	466 100	484 000	709 000
Private	1 618 100	1 202 000	1 102 000
TOTAL	3 601 000	3 331 100	3 216 000

2. Mid Zone

The Mid Zone harvest volumes (Table 4) will increase in 2005 compared to the 1985 volume. The increased harvest which is forecast is required to balance harvest reductions in the South Zone. Within the zone, the harvesting of private, TFL, and TSA land will increase and offset the reduction in volumes from the Timber and Pulp Licences.

Within the zone, most areas will have sufficient volumes of timber available in 20 years, although several operations will be re-evaluating their annual allowable cuts in the next few years.

TABLE 4. Summary of Mid Zone Harvest Volumes (m^3).

Tenure	Actual Harvest 1985	Forecast Harvest 1995	Forecast Harvest 2005
TFL	5 941 200	6 959 000	6 760 500
OTT	1 120 000	1 049 000	122 000
TSA	1 349 300	1 523 000	1 943 000
Private	572 700	665 000	724 500
TOTAL	8 983 200	10 196 000	9 550 000

3. North Zone

The North Zone's harvest (Table 5) is expected to decrease from 1985 to 2005. The harvest from TFLs, Timber and Pulp Licences, and private land will all decrease but will increase from the TSAs. Harvesting levels could be increased if a market is found for the large volume of overmature timber on the north mainland.

TABLE 5. Summary of North Zone Harvest Volumes (m^3).

Tenure	Actual Harvest 1985	Forecast Harvest 1995	Forecast Harvest 2005
TFL	2 268 300	2 221 000	2 101 000
OTT	60 000	176 000	0
TSA	192 000	234 000	300 000
Private	0	10 000	0
TOTAL	2 520 300	2 641 000	2 401 000

4. Comments on Coast Logging Projections

FERIC feels that the projected harvest levels in the three zones are reasonably estimated. Harvesting plans for Timber and Pulp Licences, TFLs, and TSAs reflect Ministry regulatory requirements. The estimates given by the divisional engineers during the survey were reviewed by the regional engineers and Ministry resource officers and were considered realistic.

While the projected harvests do not indicate any significant shifts in the volume logged, five major factors indicate that the timber supply on the Coast will be more expensive to recover and may not be sufficient to meet the future demand:

1. Many of the remaining Timber and Pulp Licences are located along the Coastal inlets, in fringes above old logging and below non-merchantable timber, and in blocks beyond previous drainage development. These areas are expensive to develop because of high road-construction costs, long distances of road reconstruction, extensive drainage-structure replacement, camp establishment, and barging costs.

2. The total estimated old-growth inventory may not be available. The high volumes of decadent timber currently being encountered in localized areas of high elevation hemlock and balsam stands throughout the Coast may indicate a lack of good inventory data and higher-than-predicted decay and waste factors.

3. The Small Business Enterprise Programs (SBEP) are increasing in status and size and as a result are becoming area based. This will result in less flexibility for operators who log volume quotas in Timber Supply Areas. There will continue to be political pressure to increase the size of the SBEP by removing volume from the Tree Farm Licences and Forest Licences.

4. The majority of individuals interviewed indicate their companies would have sufficient timber to supply their needs for the next 15 to 30 years. However, some are uncertain of the inventory beyond this period. Companies that have projected harvests beyond the current charted Forest Licence areas are having difficulty finding sufficient volumes to meet their needs.

5. The companies operating on Tree Farm Licences have reached or will shortly be reaching their designated annual allowable cut harvests. The reduced volumes of old growth remaining on the Tree Farm Licences allows less flexibility in adjusting annual allowable cut calculations.

There will be increased pressure to log second-growth, thrifty-mature, and possibly younger stands as the economically accessible old-growth volume is depleted. Caution must be exercised when harvesting these stands to ensure age and volume imbalances that will affect the long-term timber supply are not created.

There will be fewer opportunities to pick up extra volumes from alternate tenures. Divisions will have to harvest their secured timber inventory and charted areas. Additional volumes could be obtained by increasing the volume of timber recovered and by increasing the utilization level.

Equipment utilization overall will probably decrease because much of the remaining old-growth timber is located in small blocks. Utilization will be further reduced as the need to move equipment between Coastal inlet operations increases.

B. Summer and Winter Operations

Overall, the proportion of summer to winter logging operations for the Coast and each of the zones will remain basically unchanged for the next 20 years (Table 6) mainly because limited area is available for winter logging. The South Zone areas that could log more winter wood in the future would have to reduce their summer operations.

TABLE 6. Summer and Winter Logging: Percentage of Total Harvest.

Zone	Logging Season	Actual 1985	Forecast 1995	Forecast 2005
South	Summer	75	75	76
	Winter	25	25	24
	Total	100	100	100
Mid	Summer	63	64	65
	Winter	37	36	35
	Total	100	100	100
North	Summer	70	71	71
	Winter	30	29	29
	Total	100	100	100
TOTAL	Summer	67	68	68
	Winter	33	32	32
	Total	100	100	100

The operating season is at a minimum for some of the South Zone operations (as governed by their basic equipment fleet), and periodic shutdowns for summer and winter weather conditions can be accommodated by extending logging into the winter periods or by multiple shifting of equipment. Changes in the summer and winter operating seasons would result in inefficiencies (i.e., increasing the work year would reduce equipment utilization, and decreasing the work year would require more equipment that may not be fully utilized). This indicates equipment levels in the South Zone may decrease to minimum levels in most operations or adjacent operations may consolidate.

The Mid Zone operating seasons are relatively fixed due to summer and winter weather shutdowns and shutdown for vacations. Because the areas suited for winter logging are decreasing, there will be an increased need to meet the budgeted harvest during the spring and fall periods. Equipment utilization in the Mid Zone will have to increase during these periods, e.g. by double shifting, if the current equipment fleet is not expanded or additional units added. Increasing the fleet may mean lower utilization year around.

The North Zone operating season is not affected by weather as much as the South and Mid Zone. Operators will try and minimize the amount of winter logging to preserve suitable areas for the future. Operators are attempting to maintain year-around operations to ensure stable crews and communities exist. Equipment usage will probably increase year around, and multiple shifting will be used to increase production rather than increasing equipment and crew size to accommodate increased harvesting levels.

C. Production per Operating Day

The number of operating days per year (Table 7) will probably remain the same or may increase slightly during the next 20 years. Licensees will try to maintain year-round, or at least regular, seasonal operations in order to maintain a skilled crew.

TABLE 7. Summary of Average Operating Days.

Zone	No. of Days per Year		
	Actual 1985	Forecast 1995	Forecast 2005
South - Average	143	149	149
- Range	115-220	131-220	131-220
Mid - Average	184	188	187
- Range	140-210	140-210	140-210
North - Average	231	231	231
- Range	210-205	210-275	210-275
TOTAL - Average	181	187	186
- Range	115-220	130-275	130-275

The 1995 and 2005 operating days per year forecasts are presented in terms of budgeted operating days, whereas the 1985 figure indicates the actual number of days operated. In reality, when the budgeted volumes are reached, the operations cease logging and thus the forecast is only a rough estimate. The table, therefore, indicates a trend to maintain the current operating year.

The length of the operating year in the South Zone is already approaching the minimum for efficient operation. Most operations feel there

would be no significant change in the number of operating days, and four of the ten operations will continue to log only during the summer period. Consolidation of operations may occur if budgeted volumes can be achieved in less than 140 to 160 days. Equipment fleets would be expected to decrease with the reduced harvest levels for the next 20 years if the operating year remains the same.

The Mid Zone's operating year is largely governed by the length of summer and winter shutdowns for weather, log-market demand, and maintenance. Four of the thirteen operations indicate their operating season would be decreasing to accommodate decreases in the projected harvests. The remaining operations indicate the operating year would probably remain the same as 1985. Equipment utilization will probably increase to accommodate the increased harvest levels.

The operating year in the North Zone is not expected to change. Equipment utilization will increase over the next 10 years, e.g. by multiple shifting, if new equipment is not added to harvest the increased volume. The equipment fleet will probably decrease during the period 1995 to 2005.

D. Logging Terrain

More than 50% of the respondents feel that ground roughness, steepness of sideslopes, and the elevation of operating areas would remain nearly the same as 1985 conditions (Table 8).

TABLE 8. Summary of Changes in Logging Terrain.

Zone	Terrain Condition	No. of Respondents		
		Smoother/ Flatter/ Lower	Similar	Rougher/ Steeper/ Higher
South	Roughness	0	8	2
	Steepness	1	7	2
	Elevation	4	2	4
Mid	Roughness	1	6	6
	Steepness	2	4	7
	Elevation	2	10	1
North	Roughness	0	3	1
	Steepness	0	3	1
	Elevation	0	3	1
TOTAL	Roughness	1	17	9
	Steepness	3	14	10
	Elevation	6	15	6

Ground roughness and steepness in the South Zone will remain similar to 1985 conditions because most areas have been fully accessed and the next 20 years of logging will take the remainder of the old-growth timber. Harvesting will shift to: stands at the back of previously logged drainages where timber was too costly to harvest in previous years; higher elevations; and firebreaks that can now be logged. Timber will also be harvested at lower elevations as the second-growth stands become available for logging.

Ground roughness will remain the same or become rougher in the Mid Zone while the general logging areas will be at lower elevations. Steepness of sideslopes will increase. Licensees in the middle of Vancouver Island indicate their future operating areas may be in lower-elevation locations, however, the timber from these blocks would have to be hauled over high-elevation passes that are subject to winter-weather conditions. Licensees on northern Vancouver Island indicate that most of the better ground has been logged and newly developed drainages have similar or more difficult terrain than current areas. Licensees along the mainland Coast indicate that logging would progress to new areas as ground conditions become too difficult in current areas. The new areas have similar characteristics to current operating areas.

The majority of respondents in the North Zone indicate ground roughness, sidehill steepness, and elevations of logging will remain nearly the same because most areas have been developed with a basic road network.

On the Coast, harvest volumes on slopes of greater than 50% will increase in the next 20 years, and timber on slopes less than 30% will decrease (Table 9). Although the South Zone will have more timber on the gentle slopes, the Mid and North Zones will have to log more timber on steeper slopes.

TABLE 9. Timber on Different Slopes: Percentage of Total Harvest.

Zone	Slope Class	Actual 1985	Forecast 1995	Forecast 2005
South	<30%	21	25	29
	30-50%	40	37	36
	50%	39	38	35
	Total	100	100	100
Mid	<30%	30	25	22
	30-50%	40	40	40
	50%	30	35	38
	Total	100	100	100
North	<30%	32	24	22
	30-50%	46	45	46
	50%	22	31	32
	Total	100	100	100
TOTAL	<30%	28	25	24
	30-50%	41	40	40
	50%	31	35	36
	Total	100	100	100

The increased proportion of timber on slopes less than 50% and the decrease in timber on slopes greater than 50% in the South Zone indicates a potential for ground-based harvesting systems. Cable systems will remain the dominant system in the Mid and North Zones because of the increasing proportion of timber is on slopes greater than 50 percent.

Road construction in the South Zone will probably become easier as the proportion of timber on steep slopes decrease. Road construction in the Mid and North Zones will increase in difficulty as more operating areas are accessed on slopes greater than 50 percent.

Overall, Coast logging above 750-m elevation will remain essentially unchanged until 2005 (Table 10). However, the South Zone is forecast to switch the majority of its logging operations to elevations less than 750 m within 20 years, while the Mid Zone will remain at current elevations. No large volumes of timber are growing at elevations above 750 m in the North Zone.

The South Zone shift in timber from higher elevation to lower elevation will probably mean the operations will be less subjected to winter-weather constraints. The Mid Zone shift to higher-elevation harvesting will probably mean logging will be subjected to increased shutdowns due to winter weather and will have to depend upon spring and fall logging periods to recover lost production.

TABLE 10. Timber at Different Elevations: Percentage of Total Harvest.

Zone	Elevation	Actual 1985	Forecast 1995	Forecast 2005
South	<750 m	38	50	60
	>750 m	62	50	40
	Total	100	100	100
Mid	<750 m	81	76	75
	>750 m	19	24	25
	Total	100	100	100
North	<750 m	99	99	99
	>750 m	1	1	1
	Total	100	100	100
TOTAL	<750 m	74	75	75
	>750 m	26	25	25
	Total	100	100	100

E. Timber Characteristics

The responses to a general question on timber characteristics are presented in Table 11.

TABLE 11. Summary of General Timber Characteristics.

Zone	Timber Characteristics	No. of Respondents		
		Different/ Smaller/ Reduced	Similar	Bigger/ Increased
South	Species	3	7	N/A
	Size	6	3	1
	Recovery	4	3	3
Mid	Species	5	8	N/A
	Size	6	6	1
	Recovery	7	4	2
North	Species	0	4	N/A
	Size	2	2	0
	Recovery	3	0	1
TOTAL	Species	8	19	N/A
	Size	14	11	2
	Recovery	14	7	6

Timber species are forecast to change very little. The South Zone expects to harvest a greater proportion of Douglas-fir as second-growth logging increases in volume. An increase in old-growth Douglas-fir is also expected as the remaining firebreaks and leave strips are liquidated. Greater proportions of hemlock/balsam are expected to be harvested in the Mid Zone and Sitka spruce volumes will probably decrease. No changes are foreseen in the North Zone.

Although the majority of respondents say that timber size will decrease, nearly as many say timber size will remain the same. The South Zone is the only area that indicates a strong trend for tree size reductions and this response is based on the premise that second-growth trees are smaller than old-growth trees.

The reduction in recovery for the Mid and South Zones is primarily a result of previous logging where the best timber was harvested first and the timber available in the future is of lower quality than current stands. Several areas in the North Zone are experiencing a high percentage of decay in their stands and are uncertain of whether or not this will continue in the future. The overall recovery in the South Zone is nearly constant. Six of the ten licensees indicate their timber would either remain the same or improve as a result of harvesting increased volumes of good-quality second-growth as opposed to the overmature decadent old-growth timber currently being harvested.

Table 12 gives details on stand characteristics. In the South Zone the changes in age class, height class, volume per hectare, and piece size all reflect the previously identified shift from old-growth to second-growth

stands. Although age and height class remain essentially the same in both the Mid and North Zones, the respondents predict declines in piece average and volume per hectare.

TABLE 12. Summary of Stand Characteristics.

Zone	Stand Characteristics	Elevation	Actual 1985	Forecast 1995	Forecast 2005
South	Age Class	<750 m	7.7	7.0	5.9
		>750 m	8.4	8.8	7.3
	Height Class	<750 m	4.8	4.8	4.7
		>750 m	4.7	5.0	4.5
	Vol/ha (m^3/ha)	<750 m	630	630	630
		>750 m	630	580	540
	Piece Size (m^3)	<750 m	1.4	1.2	1.2
		>750 m	1.4	1.3	1.1
Mid	Age Class	<750 m	9.0	9.0	9.0
		>750 m	9.0	9.0	9.0
	Height Class	<750 m	4.9	4.7	4.5
		>750 m	4.5	4.5	4.5
	Vol/ha (m^3/ha)	<750 m	720	700	680
		>750 m	560	540	530
	Piece Size (m^3)	<750 m	1.6	1.5	1.3
		>750 m	1.5	1.2	1.2
North	Age Class	<750 m	9.0	9.0	9.0
		>750 m	9.0	9.0	9.0
	Height Class	<750 m	4.3	4.4	4.5
		>750 m	4.0	4.0	4.0
	Vol/ha (m^3/ha)	<750 m	460	460	450
		>750 m	190	190	180
	Piece Size (m^3)	<750 m	1.6	1.5	1.4
		>750 m	1.6	1.5	1.4

The South Zone will recover 8% more pieces to recover 10% less volume by 2005, the Mid Zone will recover 30% more pieces to recover 6% more volume, and the North Zone will recover 9% more pieces for 5% less volume. Stand characteristics will probably influence equipment requirements in the South and the Mid Zones more than in the North Zone.

Road construction requirements will also increase because less timber is recovered.

Recovery predictions in the North Zone are heavily influenced by one licensee which expects its recovery to increase 10% in the next 20 years through reduced breakage and increased utilization. The three other licensees forecast their recovery to decrease by approximately 7 percent.

Extraction and loading equipment will be the most affected by increases in number of pieces. Extraction equipment should be able to handle bunched turns or be able to accumulate full payloads. Ground-skidding equipment should have a potential to replace cable operations on slopes less than 30 percent. Loaders would require fast cycle times. There would also appear to be potential for mechanical felling to increase extraction productivity by creating bunches, especially on slopes less than 50 percent.

The decreases in piece size may not warrant decreases in equipment size. Multi-piece handling of future small pieces may actually mean increases in the current single-log payload (i.e., a grapple yarder that averages one 1.6-m^3 log per turn today, may be yarding two 1.2-m^3 logs by 2005). Tree-length logs will be handled through all the harvesting phases.

The decreased pieces and tree size will also reduce the need for bucking at the stump. Logs will require less manufacturing for upgrading because of a more uniform quality and the desire to avoid short lengths.

The need for limbing will be increased if utilization levels are increased and the smaller-diameter tree tops are included in recovery. The majority of logs will have to be limbed because of the tree-length harvesting system. Mechanical limbing and trimming may be the most efficient and safest method for extensive delimbing.

Table 13 shows the number of years that old-growth timber will be available for logging. Old-growth timber will be available for less than 30 years in the South Zone and will be depleted in three operations within the next 10 years. Most operations in the Mid Zone have sufficient old growth for 20 to 30 years, while old-growth volumes in the North Zone vary from 10 to 40 years.

TABLE 13. Number of Years of Old-Growth Timber Remaining.

Zone	Years of Old Growth Remaining	Number of Respondents
South	<10	3
	11-20	5
	21-30	2
	31-40	0
	41-50	0
	>50	0
	Total	10
Mid	<10	0
	11-20	1
	21-30	9
	31-40	1
	41-50	0
	>50	2
	Total	13
North	<10	0
	11-20	1
	21-30	1
	31-40	1
	41-50	0
	>50	1
	Total	4
TOTAL	<10	3
	11-20	7
	21-30	12
	31-40	2
	41-50	0
	>50	3
	TOTAL	27

1. Second-Growth Volumes

The logging of second-growth stands will occur mainly in the South Zone and, to a limited extent, in the Mid Zone (Table 14). Second-growth stands are being logged as old-growth stands are depleted.

TABLE 14. Old-Growth and Second-Growth Logging Volumes. (Percentage of Total Harvest.)

Zone	Stand Characteristics	Actual 1985	Forecast 1995	Forecast 2005
South	Old Growth	77	68	53
	Second Growth	23	32	47
	Total	100	100	100
Mid	Old Growth	99	95	91
	Second Growth	1	5	9
	Total	100	100	100
North	Old Growth	100	100	100
	Second Growth	0	0	0
	Total	100	100	100
TOTAL	Old Growth	94	90	85
	Second Growth	6	10	15
	Total	100	100	100

Some of the second-growth stands that are designated for logging in the South Zone have originated from fires and not from previous logging. As a result, the terrain may not be as gentle as normally associated with second-growth stands. The stands may be suited to mechanical felling, however, cable-yarding equipment could be utilized to extract the logs if bunches were created to maximize payload. Respondents said some current second-growth stands contain timber that is probably larger than the second growth to be harvested 30 to 50 years from now. This is a result of past operations deliberately delaying the second-rotation harvest to ensure there would be sufficient areas of timber at various age classes to meet future demand. Larger equipment may be required to handle this initial second growth than will be required for later stands.

F. Environmental Concerns

The majority of environmental concerns (Table 15) in all regions were related to the streamside logging of timber, preserving winter habitat and forage range for deer and elk, and recreational or visual issues. The effect of logging on slope stability is identified as a concern in the Mid Zone and in the North Zone by the Ministry of Forests and Lands.

The operation of ground-skidding equipment may be severely restricted in streamside management zones. Mechanical felling equipment may have potential to recover timber beside leave zones because trees can be selected and directionally felled away from sensitive areas.

TABLE 15. Summary of Environmental Concerns.

Zone	Environmental Concerns	No. of Respondents					% of Total Responses
		Level of Importance				Total	
		Major	Secondary	Minor	Potential		
South	Water Quality	2		1		3	30
	Streamside Mgmt.	1		4		5	50
	Wildlife Habitat	3		2		5	50
	Slope Stability					0	0
	Recreational/Visual	2			2	4	40
	Rate-of-Cut					0	0
	Park/Land Claims					0	0
Mid	Water Quality			2		2	15
	Streamside Mgmt.	9	2	1		12	92
	Wildlife Habitat	4	1	6		11	85
	Slope Stability	2	1	4	2	9	69
	Recreational/Visual		3	3	2	8	62
	Rate-of-Cut			2		2	15
	Park/Land Claims				1	1	8
North	Water Quality					0	0
	Streamside Mgmt.	2		1	1	4	100
	Wildlife Habitat				1	1	25
	Slope Stability			1		1	25
	Recreational/Visual				3	3	75
	Rate-of-Cut					0	0
	Park/Land Claims					0	0
TOTAL	Water Quality	2	0	3	0	5	17
	Streamside Mgmt.	12	2	6	1	21	79
	Wildlife Habitat	7	1	8	1	17	64
	Slope Stability	2	1	5	2	11	40
	Recreational/Visual	2	3	3	7	15	56
	Rate-of-Cut	0	0	2	0	2	8
	Park/Land Claims	0	0	0	1	1	4

Protecting or deferring old-growth areas for deer and winter range poses problems for companies which are beginning to liquidate the remaining old-growth stands. Evaluating the potential for using second-growth stands as winter habitat is identified as a priority if future harvest volumes are to be achieved.

Recreational and visual concerns may become more important in the future when logging occurs along major travel routes. The construction of a mid-Vancouver Island highway would probably involve recreational developments and require logging to satisfy visual demands that are currently not required. Road location, road-construction practices, cutblock design, and harvesting treatments would be affected by their impacts on aesthetics.

G. Road Development

Overall, the timber developed per kilometre of road will decrease (Table 16). This decrease reflects the increase in terrain difficulty, the reduction in timber quality, and the increased use of yarding cranes. Table 17 gives the expected lengths of road to be built.

TABLE 16. Summary of Timber Developed per km of Road (m^3/km).

Zone	Actual 1985	Forecast 1995	Forecast 2005
South	11 633	12 113	11 695
Mid	13 291	12 939	12 666
North	10 120	10 119	9 760
AVERAGE	11 681	11 724	11 374

TABLE 17. Summary of Road Construction Lengths (km).

Zone	Actual 1985	Forecast 1995	Forecast 2005
South	273	275	275
Mid	622	788	754
North	225	261	246
TOTAL	1120	1324	1275

The South Zone licensees indicate there will be a 4% increase in volume developed per km of road constructed while the recovered volume per hectare will remain constant over the next 10 years. This may indicate the 10-year estimated road-development figures are conservative or the recovery figures are high. Respondents in the South Zone indicate that timber developed per unit of road will increase in the 10-year period because the second-growth stands have more volume per hectare than the decadent old-growth stands they are replacing. The survey results for timber development per kilometre of road are probably conservative, as most plans for the 10- and 20-year harvest have only projected a road network and some of the short branches and spurs are not included.

Road-construction equipment fleets are not expected to increase in the South Zone because road-construction lengths remain similar to 1985 levels. Multiple shifting could be initiated if additional road is required.

Road-construction equipment utilization would have to increase significantly in the Mid Zone, or new equipment would have to be added, if the predicted increased road-construction lengths of 27% and 21% over the next 10- and 20-year period respectively are to be realized. Considering that much of this construction will be at higher elevations and on steeper slopes, it is likely that the construction season and equipment demand will be concentrated in the spring, summer, and fall periods.

The North Zone will also require greater road-construction equipment utilization or additional equipment to meet the predicted 16% increase in road-construction lengths over the next 10 years. Thereafter, the fleet would decrease. Road construction is forecast to increase in difficulty as the logging progresses into areas where nearly one-third of the timber is on slopes greater than 50%. Heavier equipment that has increased production capabilities will be required. The road-construction season is expected to be nearly uniform throughout the year, with most of the mid-slope roads developed during the drier summer period.

Road-construction lengths will consist of new and reconstructed subgrades (Table 18). Reconstructed subgrades will form an increasingly larger portion of the South Zone's construction program but will be a small portion of the Mid and North Zone's construction programs.

TABLE 18. New and Reconstructed Road: Percentage of Total Road Construction.

Zone	Road Construction	Actual 1985	Forecast 1995	Forecast 2005
South	New	98	87	80
	Reconstruction	2	13	20
	Total	100	100	100
Mid	New	100	99	96
	Reconstruction	0	1	4
	Total	100	100	100
North	New	100	100	100
	Reconstruction	0	0	0
	Total	100	100	100
TOTAL	New	99	97	93
	Reconstruction	1	3	7
	Total	100	100	100

In the South Zone, abandoned logging roads and old logging-railroad grades are reconstructed. Major expenditures are involved in such reconstruction because the original grade is too narrow for current truck roads, trestles used to maintain grade on the railroad must be replaced by combinations of bridges, culverts and fills, and the haul destinations of the railways were different from today's needs.

The majority of main roads on the South Zone have been constructed (Table 19) and the majority of construction will be on lower-standard branch roads. Most of the main roads will be in place in the Mid Zone within 20 years, although some additional roads will be required as new drainages are developed. The North Zone will continue to require higher-standard, main-road construction as logging progresses from one drainage into another.

TABLE 19. Main and Haul Roads: Percentage of Total Road Construction.

Zone	Road Standard	Actual 1985	Forecast 1995	Forecast 2005
South	Main	9	8	5
	Branch	91	92	95
	Total	100	100	100
Mid	Main	17	16	11
	Branch	83	84	89
	Total	100	100	100
North	Main	20	27	22
	Branch	80	73	78
	Total	100	100	100
TOTAL	Main	16	16	12
	Branch	84	84	88
	Total	100	100	100

Rock will continue to be a major factor in future road construction on the Coast (Table 20). The amount of road construction in rock is not expected to reduce until more logging begins on the lower slopes and elevations.

The increased amount of rock construction forecast in the Mid and North Zones indicates that construction progress will be limited more by the utilization of drilling equipment, blasting techniques, and the removal of blasted material. An increased number of rock-work construction sides and/or the use of highly mobile drill equipment would be expected. Rock construction can also progress during wet or snowy weather conditions, provided there is access for the crew.

TABLE 20. Conventional and Rock Road Construction: Percentage of Total Road Construction.

Zone	Construction Method	Actual 1985	Forecast 1995	Forecast 2005
South	Rock	60	63	54
	Conventional	40	37	46
	Total	100	100	100
Mid	Rock	48	56	61
	Conventional	52	44	39
	Total	100	100	100
North	Rock	27	28	30
	Conventional	73	72	70
	Total	100	100	100
TOTAL	Rock	47	52	54
	Conventional	53	48	46
	Total	100	100	100

Conventional construction progress is governed by the daily production of an excavator or crawler tractor to construct subgrade and, if required, the location of ballast sources. Overall equipment compliment for conventional construction is expected to be less than for rock construction because subgrade construction can proceed independently of ballasting. Progress of conventional construction is reduced during periods of very wet weather and ballasting usually ceases when snow is on the ground. The general trend is for conventional construction to decrease in all areas over the next 20 years, except for an expected increase in the South Zone during the 1995 to 2005 period.

The use of various ballast types is given in Table 21. The only significant change forecast is the increased use of native materials in the North Zone. This will occur because of changes in road-construction techniques.

Gravel and rock ballast are recovered from borrow pits, whereas native material is obtained from ditchlines or small pits immediately adjacent to the subgrade. Gravel ballast requires an excavator, or crawler tractor with a ripper and a loader. The use of rock ballast usually requires a drill (and/or a crawler tractor) and a loader. The use of native material requires subgrading equipment that is capable of sorting material (excavator), removing rock (ripper attachments), and carrying material relatively short distance (crawler tractors). The increased use of native ballast for road construction in the North Zone indicates there will be less demand for gravel trucks and rock drills for developing quarries and an increase in the use of excavator and crawler-tractor combinations.

TABLE 21. Road Construction by Ballast Type: Percentage of Total Road Construction.

Zone	Ballast Type	Actual 1985	Forecast 1995	Forecast 2005
South	Gravel	9	11	12
	Rock	22	21	21
	Native	69	68	67
	Total	100	100	100
Mid	Gravel	6	4	3
	Rock	42	41	44
	Native	52	55	53
	Total	100	100	100
North	Gravel	19	17	17
	Rock	74	50	46
	Native	7	33	37
	Total	100	100	100
TOTAL	Gravel	9	8	8
	Rock	44	39	39
	Native	47	53	53
	Total	100	100	100

II. CURRENT AND FUTURE EQUIPMENT COMPLEMENT

A. Road-Construction Equipment

Table 22 summarizes the existing and estimated fleet of construction equipment owned by the logging divisions included in the survey. As can be seen, the total equipment fleet on the Coast will decline over the 10- and 20-year horizon. This may seem inconsistent with the predicted increase in the amount of road to be built and the amount of rock involved, however, it is not. The larger crawler-tractors (D8) are being replaced by excavators which are more effective, pneumatic rock drills are being replaced by hydraulic drills which are more productive, and operations are increasing the double-shifting of equipment. Consequently, there will be a decline in the total amount of equipment needed to build roads.

The front-end loader fleet is expected to decline in each zone over the 20-year period. Traditionally used to load ballast, front-end loaders now are being replaced with excavators which are more efficient for digging into quarry rock. The use of excavators increases rock recovery and reduces the amount of drilling and blasting. Most gravel trucks used to haul the ballast are, and will be, conventional 9- to 12-m^3 tip trucks. The articulated multi-drive dump trucks are not forecast to increase their present market share.

TABLE 22. Summary of Road Construction Equipment.

Zone	Equipment	Age of Units in 1985 (yrs)			No. of Pieces		
		0-5	6-10	11+	Actual 1985	Forecast 1995	Forecast 2005
South	Crawler Tractors	3	25	17	45	36	36
	Hydraulic Excavators	20	8	3	31	30	30
	Pneumatic Drills	3	15	23	41	18	17
	Hydraulic Drills	1	0	0	1	9	9
	Front-End Loaders	1	12	6	19	17	17
	Highway Gravel Trucks	0	4	2	6	11	11
	Off-Highway Gravel Trucks	0	10	22	32	28	28
	Off-Highway Multi-Drive	1	0	0	1	1	1
					176	150	149
Mid	Crawler Tractors	17	27	17	61	55	55
	Hydraulic Excavators	65	23	0	88	91	91
	Pneumatic Drills	12	35	13	60	41	40
	Hydraulic Drills	9	0	0	9	19	19
	Front-End Loaders	1	15	13	29	25	23
	Highway Gravel Trucks	0	11	0	11	12	12
	Off-Highway Gravel Trucks	5	7	46	58	57	56
	Off-Highway Multi-Drive	3	0	0	3	3	3
					319	303	299
North	Crawler Tractors	3	16	3	22	21	20
	Hydraulic Excavators	13	4	1	18	19	19
	Pneumatic Drills	3	8	4	15	8	8
	Hydraulic Drills	0	0	0	0	4	4
	Front-End Loaders	1	10	2	13	12	12
	Highway Gravel Trucks	0	4	14	18	18	18
	Off-Highway Gravel Trucks	0	0	2	2	3	3
	Off-Highway Multi-Drive	15	0	0	15	16	16
					103	101	100
TOTAL	Crawler Tractors	23	68	37	128	112	111
	Hydraulic Excavators	98	35	4	137	140	140
	Pneumatic Drills	18	58	40	116	67	65
	Hydraulic Drills	10	0	0	10	32	32
	Front-End Loaders	3	37	21	61	54	52
	Highway Gravel Trucks	0	19	16	35	41	41
	Off-Highway Gravel Trucks	5	17	70	92	88	87
	Off-Highway Multi-Drive	19	0	0	19	20	20
					598	554	548

The estimation of future equipment fleets is probably conservative. For example, the Mid Zone indicates the number of crawlers and excavators will decrease by 2% over the next 20 years while the drill compliment will remain nearly the same despite the estimate that road length to be constructed will be 20% greater. The crawler and excavator fleets would be expected to increase by at least 20% (35 units) and possibly more considering the construction phases will be more dependent on seasonal production, there could be less utilization of equipment due to increased rock construction, and the headings may be more isolated. If excavators are used to replace front-end loaders at quarries, the excavator fleet would increase even more. The fleet could be reduced if additional double shifting was implemented.

A revised estimate for the excavator/crawler-tractor fleet in the South Zone would be 71 units, for the Mid Zone 169 units, and for the North Zone 42 units.

Hydraulic drills are recognized as being more productive than the pneumatic drill, and their estimated fleet size in 2005 is realistic. The estimated gravel-truck fleet is also realistic.

The major trends in future road construction noted during the survey are:

- one hydraulic drill could probably replace two pneumatic drills;
- excavators will continue to use several attachments, however, few respondents were supportive of adding many more attachments. They feel the excavator would then become a very expensive multi-purpose tool carrier with low utilization;
- increased use of waterproof explosives;
- increased use of compacting equipment to take advantage of local soils for construction purposes and to reduce the set-up time of completed subgrade;
- continued use of shot-rock ballast to minimize the time required for the subgrade to set-up and because of more on-grade rock; and
- the use of chemicals that improve soil properties.

B. Felling

The use of mechanized felling was only in the experimental stages on the Coast in 1985. No survey respondent indicated that a full-time machine was available throughout the year (Table 23). The units were all contractor owned. Future equipment needs are difficult to estimate until labour/management negotiations regarding rate of pay, hours of work, and use of contractors are resolved. Respondents also indicate they need more information on the performance of current equipment in a wide variety of terrain and stand conditions before making a commitment to mechanized felling.

Mechanized felling is expected to increase in the South Zone within the next 10 years, and to a lesser extent in the Mid Zone, as second-growth stands replace old growth (Table 24). It should be noted that over 70% of the respondents do not seriously consider mechanized felling as an alternative to manual felling. The reasons given for this position are presented in Table 25. Steep terrain and large tree size are the main reasons given.

TABLE 23. Summary of Mechanical Felling Equipment.

Zone	Equipment	Age of Units in 1985 (yrs)			No. of Pieces		
		<5 Years	6-10 Years	11+ Years	Total 1985	Forecast 1995	Forecast 2005
South	Mechanical Feller	2[1]	0	0	0	2+	?
Mid	Mechanical Feller	2[1]	0	0	0	2+	?
North	Mechanical Feller	0	0	0	0	0	1+
TOTAL	Mechanical	4[1]	0	0	0	4+	1+

[1] Used only part-time during the year.

TABLE 24. Volume Felled by Various Felling Methods: Percentage of Total Harvest.

Zone	Felling Method	Actual 1985	Forecast 1995	Forecast 2005
South	Manual	99	88	84
	Mechanical	1	12	15
	Thinning	0	0	1
	Total	100	100	100
Mid	Manual	100	94	92
	Mechanical	0	5	7
	Thinning	0	1	1
	Total	100	100	100
North	Manual	100	100	100
	Mechanical	0	0	0
	Thinning	0	0	0
	Total	100	100	100
TOTAL	Manual	100	93	91
	Mechanical	0	6	8
	Thinning	0	1	1
	Total	100	100	100

TABLE 25. Why Mechanized Felling Will Not Be Used.

Zone	Reasons	No. of Respondents	%
South	Equipment not available	0	0
	Terrain no suitable	3	27
	Tree size too large	6	55
	Insufficient volume	2	18
Mid	Equipment not available	0	0
	Terrain not suitable	8	33
	Tree size too large	12	50
	Insufficient volume	4	17
North	Equipment not available	1	10
	Terrain not suitable	3	30
	Tree size too large	4	40
	Insufficient volume	2	20
TOTAL	Equipment not available	1	2
	Terrain not suitable	14	31
	Tree size too large	22	49
	Insufficient volume	8	18

The estimate of South Zone timber suited to mechanical felling appears to be low. Approximately 29% of the 1995 timber and 39% of the 2005 harvest may be available for mechanical felling. This assumes that 75% of the second-growth timber and 10% of the old-growth timber above 750-m elevation would be suitable for mechanical felling.

FERIC's revised forecast indicates the South Zone could utilize 16 to 26 mechanical felling units in 1995 and 20 to 33 units in 2005. The Mid Zone could utilize 8 to 12 units in 1995 and 11 to 18 units in 2005. The revised equipment fleet was determined by dividing the total estimated timber available (from above) by an estimated productivity (an average daily production of between 300 and 500 m^3, a 160-day year in the South Zone, and a 180-day year in the Mid Zone for each mechanical felling unit), and increasing the result by 25% to compensate for seasonal downtime and moving between blocks.

The reasons for not introducing mechanical felling equipment appear to be related to a lack of understanding of current equipment capability and the benefits such equipment could provide in terms of reducing costs. Current mechanical felling units can already negotiate 30 to 50% ground slopes and one unit is advertised with a gradeability of 150 percent. Equipment may have to be redesigned or modified to handle the soil conditions encountered on the Coast and felling head and boom assemblies developed to handle the range of tree sizes. Felling and bunching heads up to 70-cm capacity and director heads up to 90-cm capacity are currently available. Detrimental environmental disturbance caused by mechanical felling could be minimized with increased supervision and operator training.

The presence of old-growth windfalls in the felling area can be overcome by having a bucker accompany the felling machine and some of the old-growth stumps can be broken down or pushed aside. Bunching capability may be reduced in stands with numerous high stumps.

Mechanical felling offers the opportunity to fall timber for more hours per day, with greater control over the lay of the felled timber and with greater safety than manual felling. Falling small-diameter timber in bunches can increase the yarding or skidding payload. In addition, the mechanical feller's capability to directionally fall timber may offer practical methods of recovering timber along streamside management zones.

C. Extraction

Clearcut cable yarding will remain the dominant harvesting system in all regions on the Coast (Table 26). Ground skidding will increase slightly in the South and Mid Zones as more second-growth stands are logged. Ground skidding in the North Zone is expected to decrease because one of the four operations surveyed was not satisfied with its cost experience when using skidders.

TABLE 26. Ground and Cable/Aerial Extraction: Percentage of Total Harvest.

Zone	System	Actual 1985	Forecast 1995	Forecast 2005
South	Ground	4	6	6
	Cable/Aerial	96	94	94
	Total	100	100	100
Mid	Ground	2	7	8
	Cable/Aerial	98	93	92
	Total	100	100	100
North	Ground	7	4	4
	Cable/Aerial	93	96	96
	Total	100	100	100
TOTAL	Ground	3	6	7
	Cable/Aerial	97	94	93
	Total	100	100	100

The amount of timber estimated to be extracted in the South Zone using ground-based systems appears very low considering the reduced piece size and the increased volume of timber on slopes less than 50 percent. A revised estimate indicates as much as 21% of the 1995 harvest and 27% of the 2005 harvest could be ground skidded. This assumes half of the second-growth timber on slopes less than 50%, and 10% of the old-growth timber at elevations above 750 m, would be suitable for ground skidding.

1. Ground-Skidding Equipment

Table 27 gives details on the current and estimated future ground-skidding equipment fleet. The predicted reduction in the fleet is largely a result of the Mid Zone being uncertain as to future needs. One respondent indicated that a corporate policy was being awaited as whether the operation should switch from cable-yarding systems to ground-based systems. Respondents in the South Zone indicated the use of ground-based equipment would decrease from current levels because the initial second-growth stands scheduled for harvesting are more suited to cable yarding. Most of the current ground-skidding equipment is less than 10 years old, with the wide-tire skidders being the newest.

TABLE 27. Summary of Ground-Skidding Equipment.

Zone	Equipment	Age of Units in 1985 (yrs)			No. of Pieces		
		<5 Years	6-10 Years	11+ Years	Total 1985	Forecast 1995	Forecast 2005
South	Rubber-Tire Skidder	1	8	2	11	7	7
	Wide-Tire Skidder	2	0	0	2	5	5
	Crawler Tractor	0	0	0	0	0	0
	Total				13	12	12
Mid	Rubber-Tire Skidder	3	0	0	3	?	?
	Wide-Tire Skidder	3	0	0	3	?	?
	Crawler Tractor	0	0	0	0	0	0
	Total				6	?	?
North	Rubber-Tire Skidder	0	7	0	7	7+	7+
	Wide-Tire Skidder	3	0	0	3	2	2
	Crawler Tractor	0	7	0	7	7	7
	Total				17	16+	16+
TOTAL	Rubber-Tire Skidder	4	15	2	21	14+	14+
	Wide-Tire Skidder	8	0	0	8	7+	7+
	Crawler Tractor	0	7	0	7	7	7
	Total				36	28+	28+

FERIC's revised forecast indicates the South Zone could utilize 28 to 37 ground-skidding units in 1995, and 35 to 46 units in 2005. The Mid Zone could utilize 18 to 24 units in 1996 and 23 to 31 units in 2005. The revised equipment fleet was determined by dividing the total estimated timber available (from above) by the estimated productivity (an average daily production of between 150 and 200 m^3, a 160-day year in the South Zone, and a 180-day year in the Mid Zone for each ground-skidding unit was assumed), and increasing the result by 25% to compensate for moving between blocks and seasonal downtime.

The common reasons given by respondents for not accepting ground-skidding are given in Table 28. The main reasons are:

- the Ministry of Forests and Lands, the Ministry of Environment and Parks, and the Department of Fisheries and Oceans staff are concerned about the potential for site and soil degradation and are reluctant to approve the use of ground-skidding equipment on a large scale;

- terrain conditions are too rugged and stumps and windfalls prevent equipment travel;

- there is no significant improvement in cost relative to cable logging;

- timber is too large for equipment or not in sufficient volume to make ground skidding practical; and

- owner/operators are thought to be the only practical method for maintaining production and there is difficulty in introducing new contractors into logging operations covered by the current IWA contract.

TABLE 28. Why Ground-Skidding Equipment Will Not Be Used.

Zone	Reasons	No. of Responses	%
South	Equipment not available	1	10
	Terrain not suitable	6	60
	Timber too large	2	20
	Insufficient volume	0	0
	Environmental	4	40
	Volume not required	0	0
	Cable yarding cost is similar	5	50
	Contractor needed	2	20
Mid	Equipment not available	1	8
	Terrain not suitable	4	31
	Timber too large	4	31
	Insufficient volume	1	8
	Environmental	7	54
	Volume not required	1	8
	Cable yarding cost is similar	3	23
	Contractor needed	4	31
North	Equipment not available	1	25
	Terrain not suitable	1	25
	Timber too large	2	50
	Insufficient volume	2	50
	Environmental	3	75
	Volume not required	1	25
	Cable yarding cost is similar	1	25
	Contractor needed	0	0
TOTAL	Equipment not available	3	11
	Terrain not suitable	11	41
	Timber too large	8	30
	Insufficient volume	3	11
	Environmental	14	52
	Volume not required	2	7
	Cable yarding cost is similar	9	33
	Contractor needed	6	22

The Coast industry's reluctance to maximize the use of ground-based systems appears to be based on perceived limitations rather than fact. Ground skidding can create considerable impacts to sites and reduce water quality if extensive supervision and planning are not undertaken. Many of the detrimental impacts of ground skidding on site productivity have not been thoroughly documented: more applied research is needed to resolve this issue. Large tree and log sizes would not be deterents if larger equipment (with low ground-pressure capability) is utilized or developed. Ground-skidding equipment can operate on slopes greater than 30% as demonstrated by the Interior's use of small crawler tractors, the FMC flexible-track skidder, and the rubber-tired skidder equipped with wide tires.

2. Cable-Yarding Equipment

Table 29 gives details on the cable-yarding equipment fleet of the divisions surveyed. As can be seen, the number of cable machines will decline over the 20-year period. The most significant decrease will be in highlead towers which will be replaced with grapple yarders and yarding cranes. These latter machines can be double-shifted which explains the overall reduction in the machinery fleet. Also, they have a higher productivity per machine hour than a highlead tower when in similar terrain. However, the highlead tower will remain as a cable-yarding option because it can operate in areas that the yarding crane and grapple yarder cannot.

The estimates for the highlead fleet appear to be very conservative for all regions. Significant underestimations of the highlead fleet are indicated in the Mid Zone for 1995 and in the South and Mid Zones in 2005. Running-skyline yarders with grapples may recover some of the highlead timber, however, additional running-skyline units would have to be considered.

Survey respondents indicate that future running-skyline yarders would be required to double shift more often than in 1985. The fleet estimates for running-skyline yarders appear realistic if one-third of the units are double shifted.

If the cable-yarded volume forecast for the South Zone is reduced by additional ground-skidded volume, changes in the equipment compliment would probably occur. Most likely, grapple yarders would be reduced rather than highlead or skyline yarders. Four to five units could be replaced or double shifting could be reduced.

The estimate of skyline tower yarders and long-line skyline machines is probably conservative also. Few operations have sufficient timber to justify a full-time skyline yarder and most licensees did not know how much volume would need to be recovered by these systems. Helicopter logging was proposed as an alternative to investing in a skyline yarder if only small blocks of timber were available.

TABLE 29. Summary of Cable-Yarding Equipment.

Zone	Equipment	Age of Units in 1985 (yrs) <5 Years	Age of Units in 1985 (yrs) 6-10 Years	Age of Units in 1985 (yrs) 11+ Years	Total 1985	Forecast 1995	Revised Forecast 1995	Forecast 2005	Revised Forecast 2005
		No. of Units							
South	Highlead Tower	0	8	36	44	22	27	13	26
	Running Skyline:								
	Grapple Yarder	4	5	19	28	22	-	23	-
	Yarding Crane	7	3	1	11	13	-	13	-
	Total Running Skyline	11	8	20	39	35	44	36	42
	Tower Skyline	0	2	6	8	3	2	3	1
	Long-Line Skyline	0	0	0	0	0	0	0	0
	Total Yarders	11	18	62	91	60	73	52	69
	Backspars:								
	Crawler Tractors	0	0	13	13	9	-	9	-
	Excavators	0	1	13	14	20	-	20	-
	Total Backspars	0	1	26	27	29	29	29	29
Mid	Highlead Tower	2	7	90	99	61	82	60	70
	Running Skyline:								
	Grapple Yarder	10	32	11	53	52	-	52	-
	Yarding Crane	10	0	0	10	18	-	18	-
	Total Running Skyline	20	32	11	63	70	75	70	82
	Tower Skyline	0	0	0	0	1	1	2	2
	Long-Line Skyline	0	0	0	0	?	1	?	2
	Total Yarders	22	39	101	162	132+	159	132+	156
	Backspars:								
	Crawler Tractors	0	0	17	17	8	-	8	-
	Excavators	0	12	17	29	42	-	42	-
	Total Backspars	0	12	34	46	50	50	50	50
North	Highlead Tower	0	0	22	22	14	16	14	10
	Running Skyline:								
	Grapple Yarder	5	4	7	16	15	-	15	-
	Yarding Crane	6	0	1	7	9	-	9	-
	Total Running Skyline	11	4	8	23	24	27	24	25
	Tower Skyline	1	0	1	2	0	0	1	1
	Long-Line Skyline	0	0	0	0	0	0	?	2
	Total Yarders	12	4	31	47	38	43	39+	38
	Backspars:								
	Crawler Tractors	0	0	7	7	6	-	3	-
	Excavators	1	0	11	12	14	-	14	-
	Total Backspars	1	0	18	19	20	20	17	17
TOTAL	Highlead Tower	2	15	148	165	97	125	87	106
	Running Skyline:								
	Grapple Yarder	19	41	37	97	89	-	90	-
	Yarding Crane	23	3	2	28	40	-	40	-
	Total Running Skyline	42	44	39	125	129	146	130	149
	Tower Skyline	1	2	7	10	4	3	6	4
	Long-Line Skyline	0	0	0	0	0	1	0	4
	Total Yarders	45	61	194	300	230+	275	223+	263
	Backspars:								
	Crawler Tractors	0	0	37	37	23	-	20	-
	Excavators	1	13	41	55	76	-	76	-
	Total Backspars	1	13	78	92	99	99	96	96

Backspars are widely used throughout Coastal B.C. Excavators are used when traversing flat swampy terrain or when crossing a sideslope. Crawlers are used to anchor tailholds on adjacent roads. The future trend is to replace many of the crawler units with excavators.

The following trends and improvements to cable yarding were noted during the survey:

- long-distance yarding with motorized carriages is thought to be more economical and thus it is also thought that they provide a greater opportunity for recovering lower-quality timber than the helicopter;

- less expensive grapple yarders and a method to bunch logs for a full turn are required;

- equipment size could be reduced to facilitate moving on public highways;

- high-speed, long-line interlocked yarders are required for mid-slope logging;

- accessories and devices are required to improve yarder operators visibility; and

- increased tower height on yarding cranes is required to provide greater deflection and lift.

3. Alternative Logging Systems

The use of alternative systems such as long-line skylines and helicopters has not been seriously considered because of the increased costs compared to conventional yarding and because there is still enough timber available that can be harvested using conventional systems (Table 30). Two operations within the Mid Zone have had experience with helicopters and one has had experience with a long-line skyline. However, they will not continue to use these systems until they liquidate all timber that can be harvested conventionally.

The response to the question about why alternative systems are not proposed for logging indicates two things: the existing equipment requires refinement or new equipment needs to be developed. The timber suited to long-line skylines and helicopters lies beyond the reach of current equipment and is beyond economic road construction. Helicopters may be able to recover the high-quality timber in these areas. However, if substantial volumes of this economically inaccessible timber are to be recovered, then development of cable systems and hybrid heavy-lift airships is required. These systems may be better suited to handling the overall decreasing quality of timber, diminishing piece size, and reduced recovery. Logging some of the more-expensive timber at the same time as conventional stands will result in a blended cost that will keep the forest industry cost-competitive.

TABLE 30. Why Alternative Yarding Equipment Will Not Be Used.

Zone	Reasons	No. of Responses	%
South	Equipment not available	0	0
	Terrain not suitable	2	20
	Timber is too poor	0	0
	Insufficient volume	1	10
	Environmental	0	0
	Systems are too expensive	4	40
	Volume is not required	8	80
	Contractor needed	0	0
Mid	Equipment not available	0	0
	Terrain not suitable	0	0
	Timber is too poor	3	23
	Insufficient volume	2	15
	Environmental	1	8
	Systems are too expensive	6	46
	Volume is not required	13	100
	Contractor needed	1	8
North	Equipment not available	0	0
	Terrain not suitable	0	0
	Timber is too poor	2	50
	Insufficient volume	2	50
	Environmental	0	0
	Systems are too expensive	4	100
	Volume is not required	2	50
	Contractor needed	0	0
Total	Equipment not available	0	0
	Terrain not suitable	2	7
	Timber is too poor	5	19
	Insufficient volume	5	19
	Environmental	1	4
	Systems are too expensive	14	52
	Volume is not required	23	85
	Contractor needed	1	4

Poor-quality timber can be offset by creating a demand for chip fibre, creating an incentive for establishing new stands of thrifty trees and by portable chipping facilities. The scattered nature of the isolated stands can be overcome by allowing small operators to operate on a number of operations rather than a single licensee having a year-around operation. The need to reduce the cost of delivered timber can be addressed by maximizing or increasing payloads (utilizing mechanical felling and bunching), increasing the yarding inhaul and outhaul speeds, reducing capital and operating costs, and reducing hook-up and skyline-road-change times.

The major factors limiting the use of long-line and helicopter systems within a routine logging operation are the high cost of operation and the availability of a conventional timber supply in sufficient volumes to meet the harvest projections. It would appear that most licensees only consider alternative systems to recover high-value timber and not to recover budgeted volumes.

D. Processing

Mechanical processing was just being introduced to the Coast in 1985 and no surveyed operation had a full-time processor (Table 31). The future demand for these units appears to be limited to the South and Mid Zone, However, the North Zone respondents expressed interest.

TABLE 31. Summary of Mechanical Processing Equipment.

Zone	Equipment	1985 Age of Units in 1985 (yrs)			No. of Pieces		
		0-5 Years	6-10 Years	11+ Years	Total 1985	Forecast 1995	Forecast 2005
South	Processor	1[1]	0	0	1	?	?
Mid	Processor	1[1]	0	0	1	?	?
North	Processor	0	0	0	0	0	0
TOTAL	Processor	2[1]	0	0	2	?	?

[1] Used only part-time during the year.

Mechanical processing (delimbing and bucking to length) is foreseen to have the greatest potential in the South and Mid Zones (Table 32).

TABLE 32. Percentage of Total Harvest Processed.

Zone	Processing System	Actual 1985	Forecast 1995	Forecast 2005
South	Manual	0	6	21
	Mechanical	0	8	11
	Conventional	100	87	68
	Total	100	100	100
Mid	Manual	0	0	0
	Mechanical	1	7	8
	Conventional	99	93	92
	Total	100	100	100
North	Manual	0	0	0
	Mechanical	0	2	5
	Conventional	100	98	95
	Total	100	100	100
TOTAL	Manual	0	1	4
	Mechanical	0	6	8
	Conventional	99	93	88
	Total	100	100	100

It should be mentioned that many respondents did not understand the processing concept or had difficulty visualizing how it would fit into their particular operation. In addition, they felt their timber was generally too large for the equipment currently available. Other respondents were not certain how mechanical processing would fit into their existing system or what changes would be needed to make it work.

The use of mechanical processing equipment offers the potential to reduce costs and to maximize the value of second-growth logs. This can help offset increasing extraction costs. Mechanical delimbing of second-growth trees and the top logs of old-growth trees reduces the need for limbing at the stump and will be a necessity if the revised estimates for mechanical felling are to be realized. In addition, the efficient delimbing and trimming of tree-top logs offers increased cost-effective recovery of low-quality saw logs.

Processing equipment will have to be developed within a systems framework. The majority of the trees to be processed will be stored in windrows beside a road. Processing these logs requires a loader capable of reaching into the log deck, sorting logs, and lifting the selected logs clear of the log pile. The method of debris disposal and the log-sorting demands need to be considered.

A revised estimate indicates the South Zone operations could utilize 19 to 31 units in 1996 and 25 to 41 units in 2005; the Mid Zone 14 to 23 units in 1995 and 18 to 29 units in 2005; and the North Zone 2 to 3 units. The estimates are based on: processing 100% of the second-growth volume and 5% of the old growth; an estimated daily productivity of 300 to 500 m^3; a 160-day year in the South Zone, a 180-day year in the Mid Zone, and a 220-day year in the North Zone. The estimated fleet would be increased by 25% to compensate for moving and seasonal downtime.

E. Loading

Loading equipment tended to be older than other equipment, however, most of the units over 10 years old had been rebuilt (Table 33). Loader requirements are closely associated with the yarding system. Increased grapple yarding, separation of loading from the yarding phase, and double-shifting are foreseen as reasons why the number of loaders would be reduced in the future.

There is a significant decline in cable-loader usage in the South and North Zones and a lesser decline in the Mid Zone. Hydraulic loaders are easier to operate and have been found to be faster than cable loaders when working in windrows and in second-growth timber. Their introduction to the North Zone is based on their ease of operation and the belief that hydraulic loaders are more efficient than cable loaders.

TABLE 33. Summary of Loading Equipment.

Zone	Equipment	Age of Units in 1985 (yrs)			No. of Pieces		
		0-5 Years	6-10 Years	11+ Years	Total 1985	Forecast 1995	Forecast 2005
South	Line Loader	5	14	31	50	37	38
	Hydraulic Loader	9	9	19	37	47	44
	Front-End Loader	0	0	3	3	3	3
	Total				90	87	85
Mid	Line Loader	14	55	57	126	107	88
	Hydraulic Loader	2	13	19	34	43	45
	Front-End Loader	0	1	0	1	1	1
	Total				161	151	134
North	Line Loader	3	3	12	18	11	11
	Hydraulic Loader	6	3	2	11	12	12
	Front-End Loader	0	5	0	5	4	4
	Total				34	27	27
TOTAL	Line Loader	22	72	100	194	155	137
	Hydraulic Loader	17	25	40	82	102	101
	Front-End Loader	0	6	3	9	8	8
	Total				295	265	246

The loader fleet was matched to the yarder fleet in 1985 on the South and Mid Zones and was approximately 75% of the North Zone yarder fleet. The high proportion of running-skyline yarders in the North Zone allowed the loaders to operate more independently of each other compared to other regions. The South and Mid Zones have reduced their highlead-yarder fleets since 1983 and loaders may not have been reduced in similar numbers. The loaders have been used to clean up right-of-way, cherry pick, and grapple yard.

Cable loaders can be used to retrieve logs along steep sidehills, reach into windrows to pick-up the bucked ends of logs, and retrieve logs along the road right-of-way better than hydraulic loaders. Logging operations requiring only one or two loaders usually preferred the versatility of the cable loaders.

Licensees indicated they would be expecting the cable-loader fleet to contribute more than loading logs. Part of their operating time would be spent yarding logs and assisting the yarding equipment meet production requirements.

F. Hauling

Table 34 gives the population of log-hauling equipment in the survey.

TABLE 34. Summary of Log-Hauling Equipment

Zone	Equipment	Age of Units in 1985 (yrs) 0-5 Years	6-10 Years	11+ Years	No. of Pieces Total 1985	Forecast 1995	Forecast 2005
South	Highway Pole Trailer	1	20	9	30	34	35
	Highway Multi-Axle Trailer	3	4	0	7	11	12
	Off-Highway Pole Trailer	1	34	86	121	102	91
	Off-Highway Tandem	0	0	0	0	0	0
	Total				158	147	138
Mid	Highway Pole Trailer	4	11	0	15	15	16
	Highway Multi-Axle Trailer	0	0	0	0	0	0
	Off-Highway Pole Trailer	8	96	160	264	256	256
	Off-Highway Tandem	1	0	4	5	5	5
	Total				284	276	277
North	Highway Pole Trailer	4	17	14	35	22	18
	Highway Multi-Axle Trailer	4	5	0	9	21	23
	Off-Highway Pole Trailer	4	6	21	31	33	35
	Off-Highway Tandem	0	0	0	0	0	0
	Total				75	76	76
TOTAL	Highway Pole Trailer	9	48	23	80	71	69
	Highway Multi-Axle Trailer	7	9	0	16	32	35
	Off-Highway Pole Trailer	13	136	267	416	391	382
	Off-Highway Tandem	1	0	4	5	5	5
	Total				517	499	491

The logging truck fleet is generally over 6 years old and many of the units are over 11 years of age. The newer units tend to be highway multi-axle and pole trailers owned by contractors. The truck fleet configuration will shift slightly from off-highway to on-highway-size trucks. Within the highway-size segment there will be a shift from pole trailers to multi-axle trailers. If the Island Highway is reconstructed, then there could be a greater use of highway trucks than estimated.

There appears to be an increasing interest in using highway-sized log trucks. However, licensees indicated the current truck fleets will generally remain in place until the current labour agreement limiting additional contracting is resolved. The highway-size trucks offer a potential for owner/operators, are faster to load, require less space for storage of preloads, require less road surface, are more cost competitive, and repair/maintenance/inventory facilities are not required.

Licensees are also evaluating their existing haul routes to determine specifications for replacing the existing truck fleet and to evaluate alternative trucking configurations.

Off-highway haul distances will increase slightly in the South and Mid Zones and increase progressively in the North Zone (Table 35). The North Zone is continuing to develop new areas that are further from the dump, whereas the remainder of the Coast operations are hauling from developed drainages or into new dumps.

TABLE 35. Average Estimated Haul Distances (km).

Zone	Haul Road	Actual 1985	Forecast 1995	Forecast 2005
South	Highway	73	73	73
	Off-Highway	38	41	41
	Combination	88	88	88
Mid	Highway	40	5	5
	Off-Highway	29	30	30
	Combination	18	19	19
North	Highway	0	0	0
	Off-Highway	14	17	23
	Combination	56	66	68

1. Destinations of Trucked Logs

The majority of timber will continue to go from the woods to a water dump (Table 36) because the Coast mills accept the majority of logs from water. The South Zone will have a greater volume (primarily pulp logs) delivered directly to the mill. Truck hauls from the woods on northern Vancouver Island to the south Island are impractical because of traffic delays.

TABLE 36. Percentage of Total Harvest Delivered to Different Destinations.

Zone	Destination	Actual 1985	Forecast 1995	Forecast 2005
South	Central Re-Load	2	9	6
	Water Dump	96	84	85
	Mill Direct	2	7	9
	Total	100	100	100
Mid	Central Re-Load	15	14	11
	Water Dump	85	86	89
	Mill Direct	0	0	0
	Total	100	100	100
North	Central Re-Load	0	0	0
	Water Dump	67	66	65
	Mill Direct	33	34	35
	Total	100	100	100
TOTAL	Central Re-Load	10	10	9
	Water Dump	84	83	84
	Mill Direct	6	7	7
	Total	100	100	100

III. HARVESTING POTENTIAL FOR ECONOMICALLY INACCESSIBLE TIMBER

Respondents to the detailed survey indicate they will not have to log inaccessible timber for at least 20 years. Discussions with Ministry of Forests and Lands largely confirm this, but the MOFL cannot verify it until the latest Timber Supply Analysis is completed in 1988. MOFL staff in the North Zone noted one operation that was making a significant shift from conventional yarding to long-line skylines to maximize the old-growth available and to reduce road construction costs. All respondents agree that the logging of economically inaccessible timber would have to be addressed in the near future. This would ensure that the recovery of marginally inaccessible stands or opportunity timber would occur while the basic logging infrastructures (road maintenance, supervision, hauling, grading, and booming) are in place.

An additional annual volume of timber amounting to 35% of the 1985 annual harvest could be available for harvesting if alternative methods can be developed to recover stands that are uneconomical for harvesting as a result of high manual felling costs, high extraction costs, or high access development costs (Table 37). The greatest potential for increasing the volume of timber harvested is in the use of ground-skidding equipment to recover small areas of timber that are uneconomical for conventional cable development. An annual increase representing 25% of the 1985 harvest could be recovered by such ground-based systems. Development of mechanical felling equipment that can handle 40- to 80-cm trees could provide access to a Coastal timber volume representing 8% of the 1985 harvest. Recovery of timber considered too difficult for conventional systems using long-line skylines and helicopters could increase future annual harvest levels by 2% of the 1985 volume.

TABLE 37. Annual Volume of Timber Economically Available Using Alternative Methods.

Zone	1985 Actual Harvest (x 1000 m^3)	Alternative Harvesting Methods		
		Mechanical Felling Equipment (x 1000 m^3)	Ground Skidding Equipment (x 1000 m^3)	Alternative Cable/Aerial Systems (x 1000 m^3)
		Annual Volume Available		
South	3 216	847	2 295	56
Mid	9 550	338	1 281	255
North	2 401	22	224	30
TOTAL	15 167	1 207	3 800	341

Equipment development would be required to mechanically fell and buck low-quality stands. The South Zone stands occur on flat, wet, soft ground. The timber volume would be heavily reduced by decay and consist of a variety of stump diameters ranging from 40 to 60 cm with some trees exceeding 100 cm or more.

Ground-skidding equipment equipped with high-flotation tires or tracks appears to have the greatest potential to recover increased timber volumes. It is ideally suited to operating within small areas. The use of ground-skidding equipment in areas adjacent to fish stream habitat will require planning, supervision, and cooperation from regulatory agencies.

IV. THE EXPECTED FUTURE SCENARIO

The survey indicates that there will be no change in Coastal production between the years 1985 and 2005, although a peak is expected in 1995. On a regional basis, the Southern and Northern Zones will decrease in production while the Mid Zone will increase in production for the period 1985 to 2005.

Five factors identified during the discussions indicate the timber supply on the Coast will be more expensive to recover and may not be sufficient to meet future demand. These are:

1. the isolated nature of the remaining old-growth stands;

2. insufficient inventory data for the remaining old growth;

3. reduced flexibility in operating areas because Small Business Enterprise Programs are becoming area based;

4. timber requirements beyond the current charted licences appear to be insufficient; and

5. less flexibility in changing operating areas or increasing annual allowable cuts.

There will be increased pressure from the forest industry to log second-growth or younger stands and less opportunity to pick-up extra volumes from alternate tenures. Equipment utilization will probably decrease. No shift in the balance of production between summer and winter operations is expected. The survey found that there would be a slight reduction in operating days per year over the period but no major shift.

Equipment needs will be influenced by the predicted harvests, the projected number of operating days per year, and the logging season. South Zone equipment fleets will probably be reduced or adjacent operating areas consolidated. Rather than increase the equipment fleet, the Mid Zone will probably increase equipment utilization to increase the harvest. Equipment will probably have to be added to the North Zone fleet during the 1985 to 1995 period if increased utilization is not sufficient to meet the projected 1995 harvests. Beyond 1995, the North Zone equipment fleet will probably decrease.

The majority of survey respondents feel that ground roughness, steepness of sideslopes, and elevation of operating areas will not, on the average, change significantly over the 20-year period. For example, in the South Zone, although there will be more higher-elevation timber, this will be offset by more timber becoming available at lower elevations. The survey indicated that, overall, more timber will be on slopes greater than 50% and less on slopes less than 30%. The South Zone will actually have an increase of timber available on gentler slopes whereas the Mid and North Zones will reflect the overall Coastal trend. In terms of percentage of timber available at different elevations, there will be no shift on the overall Coast, although in the South Zone there will be a shift to lower elevation (<750 m) timber.

Ground-based systems will probably have greater potential in the South Zone as slope steepness, ground roughness, and elevation of operating areas decrease. Cable yarding will probably remain the dominant systems in the Mid and North Zones because terrain features are not forecast to change. Road construction is expected to become easier in the South Zone as increased logging occurs on low-elevation, previously logged areas. Road construction in the Mid and North Zones is expected to increase in difficulty.

Overall, timber species and size are forecast to change very little on the Coast. The South Zone is the exception where a shift to Douglas-fir is forecast. All respondents feel there would be a reduction in recovery over the 20-year period because of lower-quality stands. Stand characteristic changes which are predicted in the South Zone reflect the predicted shift from old-growth to second-growth harvesting. Age and height classes will stay essentially the same in the Mid and North Zones but volume per hectare and piece size are predicted to decline. Old-growth timber will be depleted within 30 years in the South Zone, while the Mid and North Zones have old-growth volumes available beyond 40 years.

The general decline in piece size means that, in order to recover the predicted volumes, it will be necessary to handle more pieces than in 1985. There will probably also be an increased utilization of the logs extracted. Ground-based extraction systems and mechanical felling will have potential (especially on South Zone slopes less than 30%). Cable yarders and loaders will be required to have fast cycle times or the ability to handle several pieces at the same time. Full-tree logging and mechanical limbing and bucking will increase. Roadside logging will continue in order to separate the extraction and loading phases. Equipment may not decrease in size. It would appear the greatest potential for changing equipment fleets will occur in the South Zone.

Timber developed per kilometre of road will decline slightly reflecting the reduction in timber quality and the increase in terrain difficulty. As a result, more road will be constructed in 2005 than 1985 to access basically the same amount of timber. Reconstructed subgrade will form a higher proportion of road construction lengths in all areas, particularly in the South Zone. In the South and Mid Zone the proportion of main to branch road construction will decrease, but in the North Zone it will increase slightly. In the North Zone, operations will still be moving into new drainages by the year 2005. Rock will continue to be a major component of road construction.

Indications are that the future harvest volumes will be more difficult to obtain and will be more expensive to develop. Overhead costs are expected to rise as allowable harvest levels reduce, equipment utilization decreases, and operations shift to developing smaller drainages. Harvesting costs will rise because of reductions in piece size and timber quality, and road costs will increase as a result of construction on steeper hillsides. Some reduction in extraction costs will occur in the South and Mid Zones as increased volumes of second-growth timber are harvested.

Environmental concerns may restrict the use of ground-based equipment in the South Zone. Mechanical felling equipment may have the potential to directionally fell timber beside or within streamside management zones. Road location, road construction, cutblock design and harvesting treatments would be influenced by their impact on aesthetics.

Respondents indicate the estimated fleet of road-construction equipment will decline over the 20-year period even though more roads will be built and it is expected more rock will be encountered. This reduction will occur because more productive equipment will be used and because of higher utilization (double shifting). Mechanical felling is predicted to increase in the South and Mid Zones but, because of the newness of the concept on the Coast, most respondents could not provide specific details. Cable logging will continue to be the dominant harvesting system, but with a slight increase in the volume harvested by ground skidding. The number of pieces of ground-skidding equipment required is forecast to decrease, however, this is probably a reflection of the uncertainty of how second-growth stands will be logged. The number of cable-yarding machines is also estimated to decline over the 20-year period. This is a result of a trend to replace highlead towers with more productive grapple yarders and yarding cranes. However, the highlead tower will still remain an important part of the cable-yarding fleet.

The use of mechanized processing equipment is expected to increase over the 20-year period particularly in the South and Mid Zones. The estimates of the increase are felt by FERIC to be conservative because mechanized processing is relatively new and most respondents had not fully considered how they could use the concept. The number of log loaders required will decrease over the 20-year period in response to the shift in type of cable-yarding equipment. The mix of log-loading equipment will shift to more hydraulic log loaders and fewer cable log loaders.

The total number of logging trucks is expected to decline and there will be a shift from off-highway and highway-size pole trailers to highway-size multi-axle trailers. Hauling distances will remain the same or decline in the South and Mid Zone, and increase slightly in the North Zone. The switch to higher-capacity multi-trailers is the main reason for the decline in the total number of trucks in the 20-year period.

The estimated road-construction fleet appears to be conservative considering the reduction in timber developed per km of road and the increased volume that is to be harvested in the Mid and North Zones. Predictions for the mechanical felling equipment fleet are also felt by FERIC to be very conservative and will increase significantly when more operations see the

benefits to be gained from their use or equipment is designed to handle the low-value timber. The benefits to be realized from using ground-based systems as opposed to cable systems is also not fully appreciated in the South and Mid Zones. If the volume of timber to be harvested by different cable systems is accurately presented by the respondents, it would appear that an over-optimistic level of production is anticipated from multiple-shifting yarding equipment. Highlead, tower skyline, and long-line skyline yarding have little potential for working multi-shift days. If the revised ground-skidding harvest volumes are achieved, the cable-yarding fleet (primarily grapple yarders) will be reduced proportionately. Predictions for the mechanical processing equipment fleet are also significantly underestimated because of a lack of information regarding the equipment and the lack of equipment to handle the timber.

There appears to be major potential for using mechanical felling, ground-skidding, and processing equipment in Coastal B.C. Mechanical felling equipment could be used to reduce felling costs, to create bunches to maximize extraction equipment payloads, to recover trees from leave strips, and to increase safety. The equipment must be capable of handling rough terrain, moving large windfalls, and operating on slopes averaging 50 percent. Ground-skidding equipment would require high flotation capability and would have to be large enough to handle the large old-growth pieces encountered within second-growth stands. Processing equipment would have to handle tree-length logs from roadside windrows.

Although all respondents agree that they would eventually have to address the question of harvesting economically inaccessible timber, they do not feel they would actually have to harvest a significant amount of timber from these stands in the next 20 years. They feel that some stands which are economically inaccessible for manual felling and cable yarding could be economically harvested using mechanical-felling and ground-skidding equipment during the 1995 to 2005 year period.

As identified in this survey, the greatest impediments to utilization of new equipment appear to be:

1. a lack of understanding of new systems, techniques, and equipment;

2. the concern that the current labour contract limits the introduction of new contract operations;

3. the impression that the future harvest volumes are available in sufficient volumes to meet the demands;

4. that existing equipment can recover the majority of the timber; and

4. a lack of demand for fibre that could be obtained form low-quality timber.

These impediments can be combined with the natural resistance to change and the need to supervise new equipment more intensively than conventional equipment.

This report indicates that licensees can expect to achieve future harvest levels with more difficulty and at higher costs. Equipment development, progressive thinking, monetary incentives, and cooperation between management and labour are required to overcome the terrain and timber characteristics that will make future logging more difficult.